ON THE FACE OF THE EARTH

by Marion Gill MacNeil

illustrated by Robert P. MacNeil

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For many years scientists have been trying to solve the mystery of the earth's beginnings. One thing they do agree on is that the earth and its planets broke away from the giant sun. Many strange creatures have been recreated by scientists, one of the most familiar being the dinosaur — a "terrible lizard" with a huge body and small brain. Many families of birds, animals and plants have become extinct because of changes in the earth's weather. About sixty thousand years ago, when the earth was warm again, a new creature arrived — a two-legged mammal — Man. He had a different kind of weapon which made him master and that was intellect. In the thousands of years that man has walked this earth, he has accomplished great wonders and he has made use of the elements of which the earth is made.

* * *

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About the Author and Illustrator:

MARION GILL MAC NEIL, the author of this book, and ROBERT P. MAC NEIL, the artist, are a husband-and-wife team who divide their time between New York City and Rhode Island. Mrs. MacNeil was born in Dover, Delaware, and is a graduate of the Corcoran Art School, in Washington, D.C. She did commerical sculpture in New York. Mr. MacNeil is an industrial designer, who took time out from his busy life to illustrate his wife's book.

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To my good friend, M.A.N.

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M. G. M.

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I STRANGE NEW WORLD

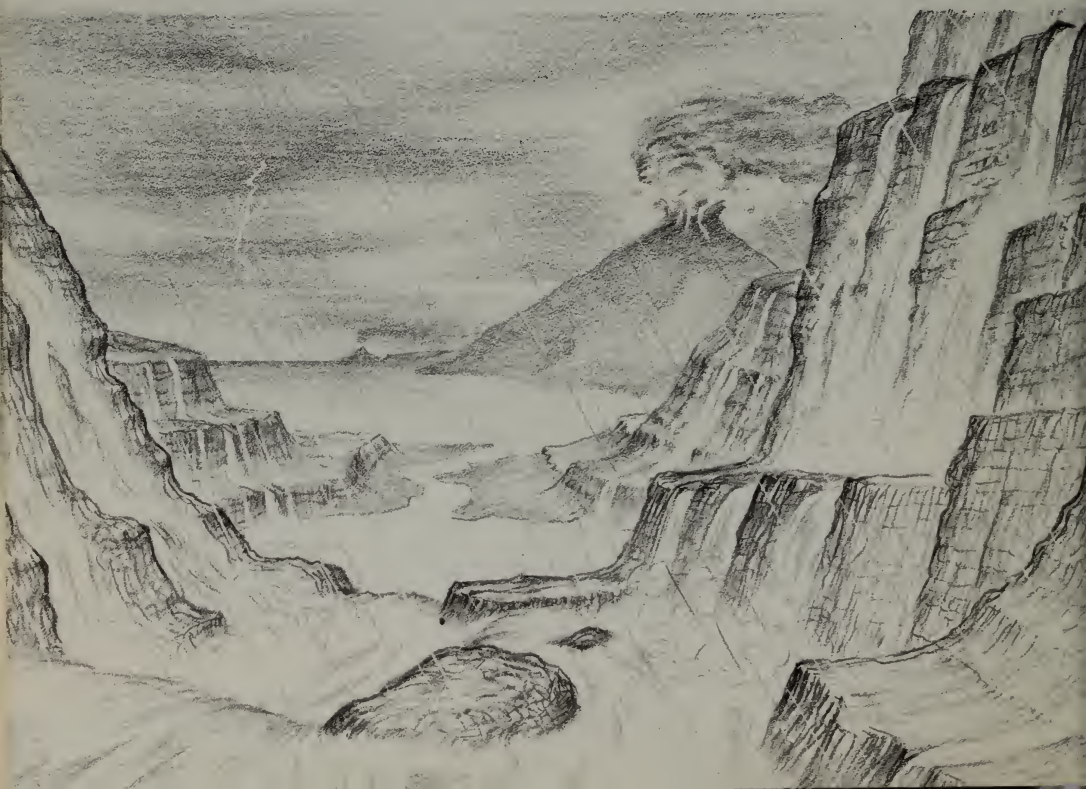
Our earth is truly a child of the sun, but just how it was born we cannot be quite certain. For many years scientists have studied the earth, the sun and the star-studded heavens, searching for clues to the earth's beginning. Perhaps they will never be able to solve the whole mystery, but on many points they do agree.

For one thing, scientists believe that the gases from which the earth and the other planets were made all broke away from the giant, flaming sun and hurtled through space. This happened at least three billion years ago. And, for a long, long time the earth itself remained a whirling mass of hot gases, very much like its parent sun.

Scientists also believe that the gases from which the earth was formed gradually cooled and combined with each other in many ways. Some of them combined to make rock, some formed water and others became air, the atmosphere that surrounds the earth like a great thick blanket.

Because of the earth's gravity (or pulling force) the rock, which was much heavier, clung to the center of the mass of hot gases. And the water remained in the air in the form of steam, for the earth was still very hot.

The gases continued to cool, the rock cooled and the water-laden air cooled. The steam condensed into drops of water. The water became rain and it showered down on the bare, ragged rocks. It filled the hollows in the rocks and there were streams, rivers, lakes and oceans.

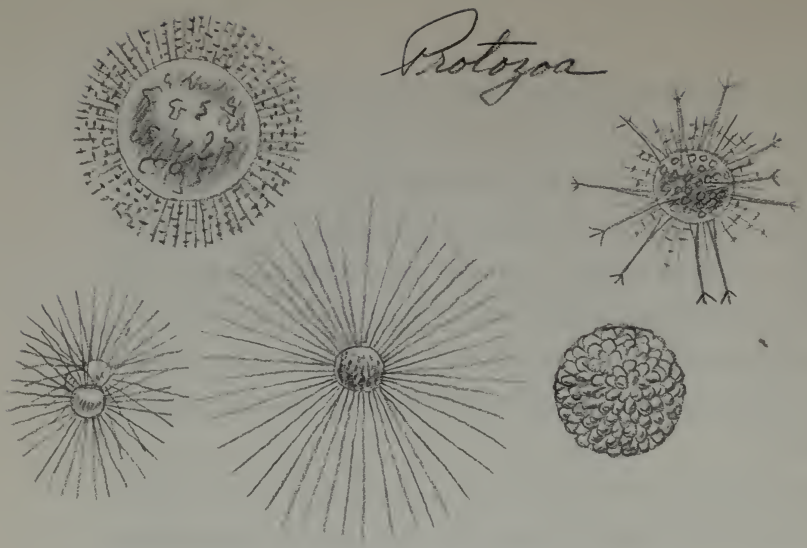


In the beginning all the waters of the earth were pure and fresh, for salt existed only in the rock. But ocean tides, stronger and higher than we can imagine, swept over the rock surface of the earth—washing, beating and grinding the salt-bearing rock into soil. Streams and rivers carried the salty soil in their downhill journey into the sea. And heat from the sun beat down upon the sea, evaporating the surface water into the air above, leaving most of the salt in the ocean waters below.

At last, in the warm, salt seas of the young earth, there began to be life. Billions of invisible living cells began floating about. They had no eyes or ears, and they could not move by themselves. They simply drifted and grew. Those first cells were neither plants nor animals—but they were alive. The cells grew and divided into two parts, and the parts grew and divided again.

Many of the cells which lived in the seas contained a green substance called chlorophyll. Those cells were phytoplankton, which means "floating, plant-like life." Sunlight, shining on the phytoplankton, gave energy to the chlorophyll. And the chlorophyll took carbon dioxide from the water and made nourishing food for the phytoplankton.

Drifting about in the water, with no power to move by themselves and with no roots to hold them in place, phytoplankton cells began clinging together. Gradually some groups developed branches and roots. With their roots they



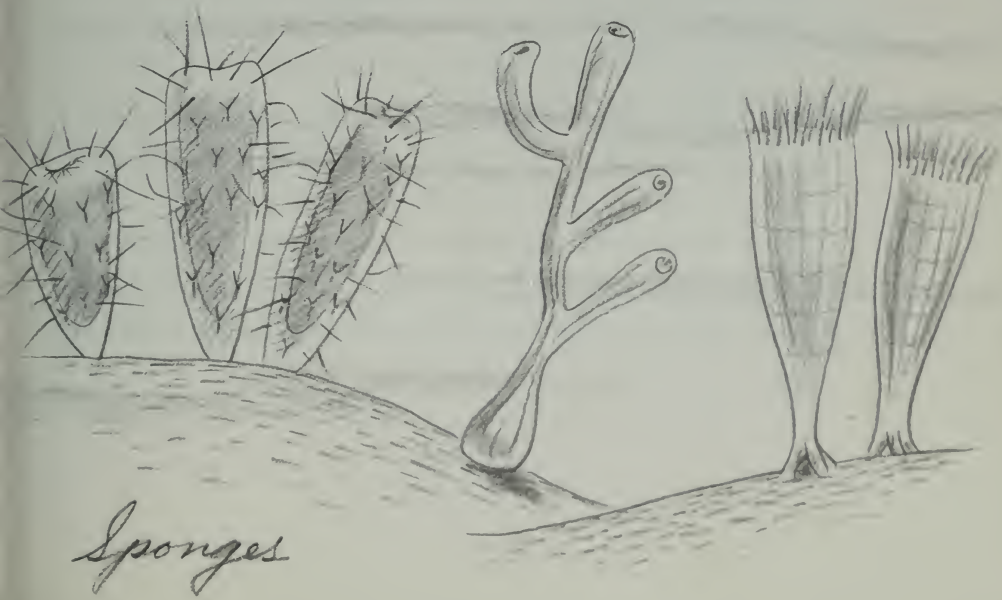
clung to rocks in the sunlit parts of the seas, their delicate branches swaying with the ocean tides. They were seaweeds. And they were the first plants.

After a time there were thousands, perhaps even millions, of different kinds of plants in the ocean. While some of them lived in deeper parts of the seas far from shore, the majority made their homes in shallower waters. There the water was warmer and sunlight, with its life-giving rays, reached them more easily. While food was more abundant in the shallow water, life was probably more difficult in other ways. Strong ocean tides often tore the plants from their rock moorings. Storms sometimes whipped up high waves which carried them ashore and left them there to die. And outgoing tides frequently abandoned them in the soft mud of swamps near the ocean shores.

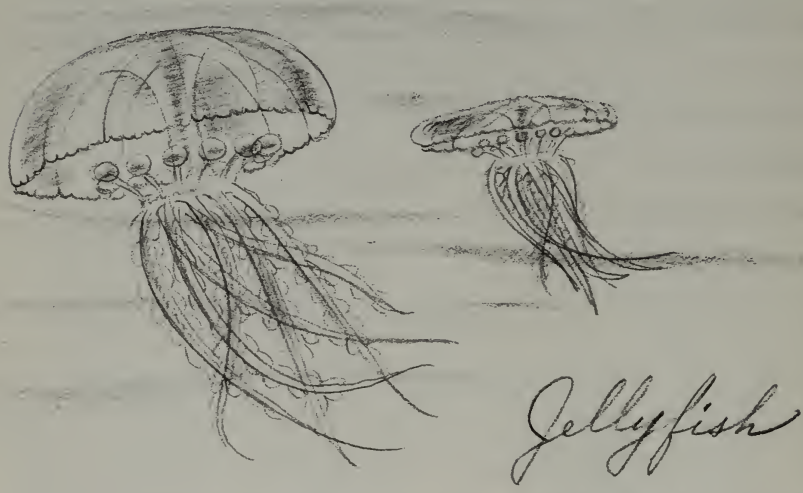
Gradually some of the plants which had been left in the swamps began pushing their roots down into the warm, wet soil. After a long time, they developed trunks, branches and featherlike leaves. There they finally made their homes, absorbing food from the sunlit air and moisture from the swampy soil. And they were the first land plants on earth.

During the millions of years when phytoplankton cells were evolving into plants, another form of life was developing in the sea. Cells which contained no chlorophyll to procure food for them began eating the phytoplankton. Those plant-eating cells were protozoa, which means "first animal-like life."

Because the protozoa, like the phytoplankton, could not move by themselves, they too began clinging together. Gradually they too developed branches and roots and clung to rocks in the seas. They were sponges. And they were the first animals.



The first animal to possess a digestive sac, or primitive form of stomach, was the jellyfish. Because of its digestive sac, the jellyfish was not dependent upon the chlorophyll-bearing phytoplankton for its food. It could eat and digest protozoa as well. The jellyfish also had tentacles, or armlike projections, with which to seize its prey. And it had a mantle, or umbrellalike body covering, with which it could move upward and downward quite easily. But, because of its soft, round-shaped body, it moved forward very slowly and thus was largely dependent upon the tides and currents in its constant search for food.



The first animal to move swiftly was the lancelet. Its long slim shape enabled it to move fast enough to escape being devoured by the slow-moving jellyfish. Its shape also

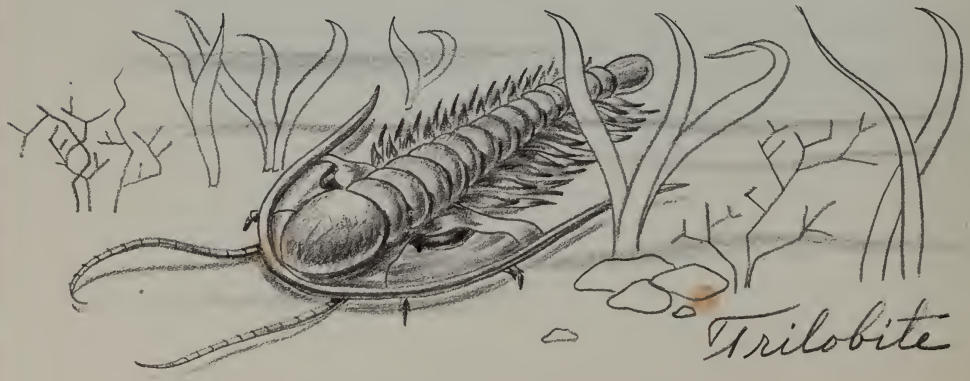
made it possible for the lancelet to swim through the ocean waves and to fight its way through strong tides.

Very slowly other animals began to develop and to change too. Some developed tough coverings with which to protect their bodies, while others grew shells in which to hide themselves. Some grew fins and tails which gave them much more speed. Others developed legs with which they could move about on the ocean bottom. And a great many of them grew eyes so that they might see where they were going.

Scientists do not know a great deal about the life of the very earliest animals. They can only suppose what most of them looked like, for few of their bodies have been preserved. But they do have a splendid record of the first animals to have tough coverings and shells. When those animals died, many of their bodies settled into the soft mud of the ocean bottom. Streams and rivers continually deposited thick layers of sand and soil upon their muddy graves. And the great weight of the ocean waters pressed down upon the sand and soil, eventually turning the deposits into rock. Thus the tough coverings and shells of many of the earth's earliest creatures were preserved in the rock. They are called fossils, which means "impressions of ancient life preserved in rock." By studying fossils scientists are able to tell what the animals looked like, how long ago they lived and sometimes even how they lived.

Among the oldest animal fossils are those of shellfish and starfish, many of which looked like creatures that live in our oceans today. Fossil shellfish look very much like the clams, oysters and scallops we find in the shallower parts of our own seas. And fossil starfish look exactly like the starfish we find tossed upon our sandy shores by the ocean waves.

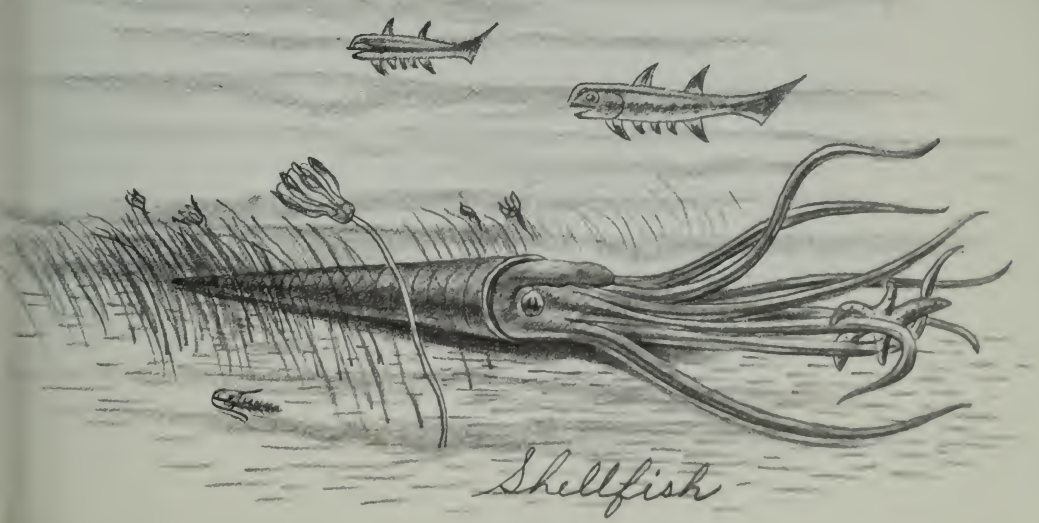
The animal which really dominated the ancient seas was the *trilobite*. A lobsterlike creature, with a tough, horny body covering, the trilobite was fairly well protected from its enemies. And, because its body covering was segmented, or divided into sections, it was able to move about quite easily. It also possessed many double-branched legs, which probably served several purposes. Scientists believe that the upper branch of each leg was used for crawling along the ocean bottom, while the lower branch was probably used for catching food and for swimming—possibly even for absorbing oxygen from the water. The trilobite also had bulging, com-



pound eyes (with thirty thousand lenses to each eye) which enabled it to see in all directions at the same time.

While the trilobite was a small creature, usually measuring a few inches in length, it was so well equipped to live and thrive in ancient seas it is small wonder that it was the ruling animal of the earth for more than three hundred million years. But, long before the trilobite finally became extinct, its existence began to be threatened by other creatures of the sea.

During the reign of the trilobite, many of the shellfish had grown to tremendous size, some of them eventually reaching a length of fifteen feet. Their shells, which were cone-shaped and covered their entire bodies, were the longest, the thickest and the hardest shells of any creatures ever known to have lived on earth. Lying on the bottom of the ocean, their mouths and tentacles protruding from the large end of their shells, the giant shellfish lay in wait for any unsuspecting prey which might swim or crawl by them. And so they caught and devoured the trilobites in great quantities.



Other enemies of the trilobite were the numerous families of fish which had begun to inhabit the seas. Early in their development, fish possessed breathing organs, or gills, which enabled them to take much-needed oxygen directly from the water in which they lived. For greater protection against other creatures in the sea, some of the fish developed scales on the outside of their bodies. And a great many of them developed very large mouths, with which they were able to swallow smaller creatures whole.

Fish also possessed backbones, or spines. Because their spines were made up of many connected links of bone, or vertebrae, they were able to turn about quickly and to move forward with great speed. Today there are many thousands of kinds of animals with spines, including man; but fish were the very first vertebrates on earth.

Thus it was that the trilobites became surrounded by better-equipped, hungry enemies. Between the giant shellfish lying in wait for them on the ocean bottom and the large-mouthed, fast-swimming fish searching for them in the waters above, the trilobites had little chance for survival. And so, about one hundred and eighty million years ago, the last of the trilobites disappeared, leaving only their fossilized bodies for us to see.

Scientists believe, however, that some of the trilobites may have changed enough to survive—not as trilobites, but as lobsters and crabs. Probably their survival was due to the

development of two strong, sharp claws—tools which lobsters and crabs use even today for clasping their food while eating, as well as for protection against their enemies.

The giant shellfish also finally disappeared but why they did is still a puzzle to scientists. However, it is believed that some of them gradually lost their hard shells and eventually became the free-swimming creatures we know today as squids, octopuses and cuttlefish.

Gradually some animals in the sea began seeking new homes in rivers and streams. Eventually some of them made their way into lakes and ponds, where life became much easier, for there the water was quiet and did not toss them about. And so, with light from the sun giving them warmth and nourishment, life flourished and grew abundant in the still waters of the earth.

Why and how animals eventually left the water to live on the land is not known. But scientists do know that many gradual body changes took place before they were able to adapt to life on the land. They developed lungs, or other breathing devices, in order to take the oxygen their bodies needed directly from the air. Many of them grew legs, in order to move about on the solid ground. And some of them developed wings so that they might move swiftly over land and water in search of food.

The earliest land creatures were born and spent the early part of their lives in the water. Their growth and body

changes were like the life processes of mosquitoes and frogs today. From small larvae, which float near the surface of still water, mosquitoes rise on their wings, full-grown, into the air. And wriggling little tadpoles, which spend their infancy in the water growing legs and lungs, emerge onto the land as leaping, husky-voiced frogs.

The first animals to seek new homes upon the shores were scorpions—distant cousins of the trilobites. And, for a long time, they were the only land animals on earth. Eventually they were followed ashore by many-legged centipedes and spiders. All those creatures looked much like their descendants do today. While we often think and speak of scorpions, centipedes and spiders as insects, they are actually insect-eating animals.

An insect is a creature which has three sections to its body—head, thorax and abdomen. An insect also has three pairs of legs. Animals, on the other hand, may have anywhere from two legs to the many legs of the centipede.

Dragonfly

The first insects were dragonflies—large four-winged creatures that had slowly developed from giant sea worms. They were very much like the dragonflies we see today, except for their size. Today the largest specimen seldom measures more than a few inches in length; but millions of years ago dragonflies often had a wingspread of more than two feet.

Among the earliest insects were cockroaches. They looked remarkably like the inch-long roaches we see today, except that they often measured four inches in length. And they were so numerous that scientists often refer to the earliest period of life upon the land as the Age of Cockroaches.

Along the shores and in the warm, wet swamps those first insects, animals and plants grew and multiplied.

II FOOTPRINTS IN THE MUD

Three hundred million years ago the climate of the earth was warm and very damp, and dense forests covered many parts of the earth's surface. There were calamites, which often grew to be thirty feet tall and were the ancestors of the small weeds we call "horsetails." There were tree ferns, which grew as high as fifty feet and were much like those in our warm

tropical swamplands. There were huge, one-hundred-foot scale trees, whose only living descendants are small club mosses and the lowly, creeping ground pines. And there were giant cordaites, which soared one hundred and twenty feet high and were the earliest ancestors of modern evergreen trees.

For a period of about sixty million years, dead leaves and branches fell from the forest trees into swamps, rivers and lakes. Sometimes the trees themselves toppled over into the water, adding to the debris. Leaves, branches and tree trunks gradually built up thick deposits of decaying plant life, and rivers and streams buried the deposits under countless tons of soil and sand. Slowly the great weight of soil and sand compressed the plant deposits into coal. It is in those coal deposits that scientists have discovered fossils of many plants, insects and animals that lived during those sixty millions of years—a period of time which they often refer to as the Coal Age.

Among the most interesting Coal Age fossils that have been discovered are those of the amphibians. By studying the fossils of the earliest amphibians, scientists have learned that they were the common ancestors of all vertebrate land animals.

The amphibians themselves had developed from air-breathing fishes—probably during long periods of drought when lakes and rivers had become stagnant or had evaporated altogether. Because the "lung" fishes were able to breathe out of the water for long periods of time, they were able to leave the poisonous stagnant water and to take their oxygen directly from the air. And, because their under-fins were thick and strong, they were able to crawl along the shores in search of food. Gradually their primitive breathing devices became true lungs, and their stubby fins became legs and

feet. Then they were able to live their entire adult lives on the land. And only then did they become true amphibians—the first vertebrate animals to live on the land and to leave their footprints in the mud.

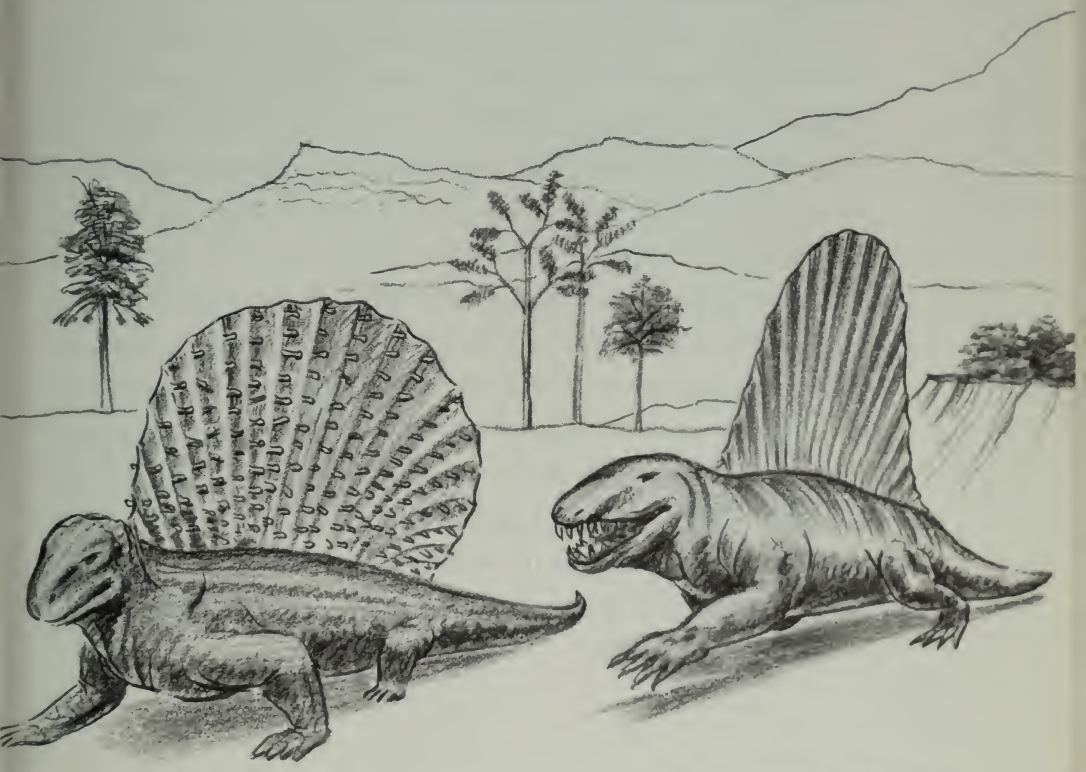
Some of the first amphibians were tiny creatures measuring only a few inches in length, while others grew to be ten feet long. But, small or large, the amphibians all had to live near the water. For, like their fish ancestors, they laid their eggs in the water, and their young grew in the water, developing lungs and legs in preparation for their life upon the land. Even adult amphibians could never wander far from the water where they had been born, for they could not drink water and so had to keep their bodies moist a great deal of the time. Thus it was that long periods of very dry weather caused a great many of the amphibians to die. Of those that did manage to survive, many eventually became the small creatures we know today as salamanders, newts, frogs and toads. Others gradually developed into a stronger and more adaptable race of creatures known as reptiles.

Young reptiles were born on the land, hatched from eggs with tough shells which protected them until they were strong enough to seek food for themselves. Instead of absorbing water through pores in their skins as the amphibians did, they were able to drink water with their mouths. Their skins were thick and leathery, serving as good protection against hot rays from the sun, as well as against their living enemies. And so, while amphibians were dying by the thousands because of droughts and scarcity of food near the water's edge, reptiles were able to wander far afield to drier lands to procure their food.

One of the first reptiles was *dimetrodon,* a fierce-looking Coal Age creature, which grew to be eight to ten feet long. It was a carnivorous reptile, which means that it killed and ate other animals, rather than living on a diet of plants. Dimetrodon's teeth were long and sharp, in order that it might easily tear the flesh from the animals it killed. Its head was large and its jaws were powerful. Along its backbone was a row of long, bony spikes, which it probably used for protection against its enemies.

Another early Coal Age creature, *edaphosaurus,* was a herbivorous reptile. This means that it lived on a diet of plants. Edaphosaurus's teeth were short and broad, in order that it might chew the leaves of the plants. It also had spikes along its spine, much like those of dimetrodon. However, each of its spikes had a crossbar, like the spar on the mast of

a sailing ship. In fact, edaphosaurus must have had the appearance of an ocean schooner under full sail. What purpose its "sails" served is not known. But at least one scientist believes they may have been devices for trapping warmth from the sun's rays and distributing that warmth throughout its body. Strange and vicious as it no doubt appeared, edaphosaurus was actually quite a harmless creature.



Edaphosaurus

Dimetrodon

Before the end of the Coal Age there were many kinds of primitive reptiles. But, large or small, they were all sluggish, slow-moving and not very strong. Gradually the early reptiles either died out or developed into larger, stronger and faster-moving reptiles called *dinosaurs*. The coming of the dinosaurs marked the beginning of what is known as the Age of Reptiles.

Dinosaur means "terrible lizard." And most of them were indeed terrible-looking, with tremendous mouths, huge bodies and very small brains. There were many kinds of dinosaurs roaming through the forests and along the shores during the Age of Reptiles. Some of them had thick, bony plates on their bodies, which resembled heavy armor plate. Some had tough horny scales instead of skin. Others had tall finlike bones projecting from their spines. Still others had long, heavy tails, which they used as powerful weapons. Many roamed through the forests or along the shores, crushing smaller creatures under their four huge feet. Others walked more upright on their two powerful hind legs, leaving their smaller forelegs free to use as weapons. While many of them were herbivorous and thus were no threat to animal life, many others were vicious killers, thundering across the countryside in search of live food.

The forests through which the dinosaurs roamed were vastly different from those of the Coal Age. Gone were the calamites and tree ferns. Gone were the towering scale trees.

And gone too were the giant cordaites. For the climate of most of the earth had grown cooler, and the air was no longer laden with moisture. In many places, where once had been lakes, marshes or rivers. now lay tracts of land that were parched from lack of rainfall. Trees that had flourished in warm damp earth now lay dead beneath the soil, and others, requiring less water, had grown up to take their places.

During the Age of Reptiles there were conifers, which were the first cone-bearing evergreen trees. There were cycads, ancestors of our own magnolia and tulip trees. There were palms, figs, poplars and trees which bore nuts. There were many kinds of lilies and flowering grasses. And the flowering trees and plants spread over many parts of the earth, furnishing excellent food for sucking insects such as bees, wasps and butterflies. They also provided plentiful nourishment for the many herbivorous dinosaurs.

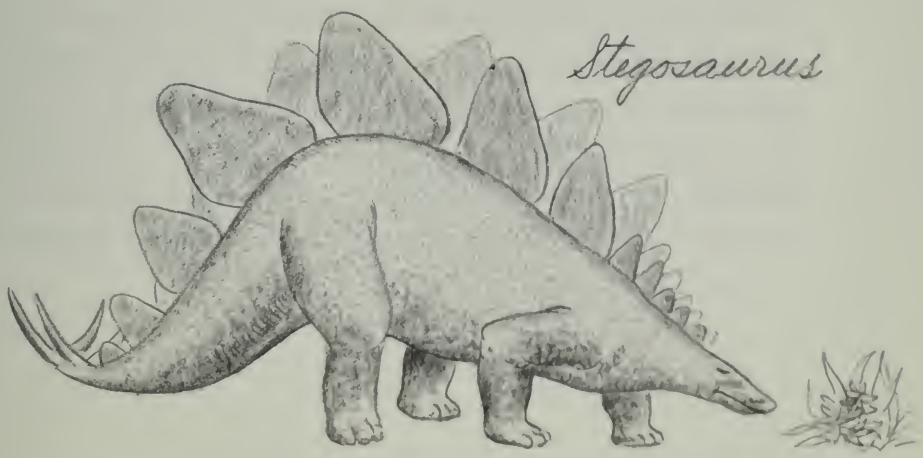
One of the first four-footed dinosaurs was *brontosaurus* —a huge, herbivorous creature which spent a large part of its time in the water. Using its great long tail to propel its body through the water, it sought out the tender water plants that floated on the surface of lake and swamp. Because of its extremely long neck, it was also able to crop leaves from plants and trees along the shore, even those which grew twenty feet above the water. Brontosaurus sometimes measured eighty-seven feet long and sixteen or more feet high, and it probably weighed as much as forty tons. Because of its tre-

mendous weight, brontosaurus moved very slowly when on land and so preferred to spend most of its time in the water, where it could move about more easily.

Then there was the giant, *diplodocus,* which looked enough like brontosaurus to be its cousin, although it was

lighter in weight and had a longer, slimmer tail. Diplodocus may have used its whiplike tail for protection against its enemies. There was *stegosaurus,* the "roofed lizard," with two rows of great bony shields down its spine and wicked-looking spikes projecting from its tail.

There were many families of two-footed dinosaurs, and probably the strangest-looking of these was *trachodon.* It had powerful hind legs for walking on the land, but its forelegs had webbed hands with which it propelled itself through the water. It had a long, flattened tail covered with scales like those of a modern crocodile. Its tail was undoubtedly strong



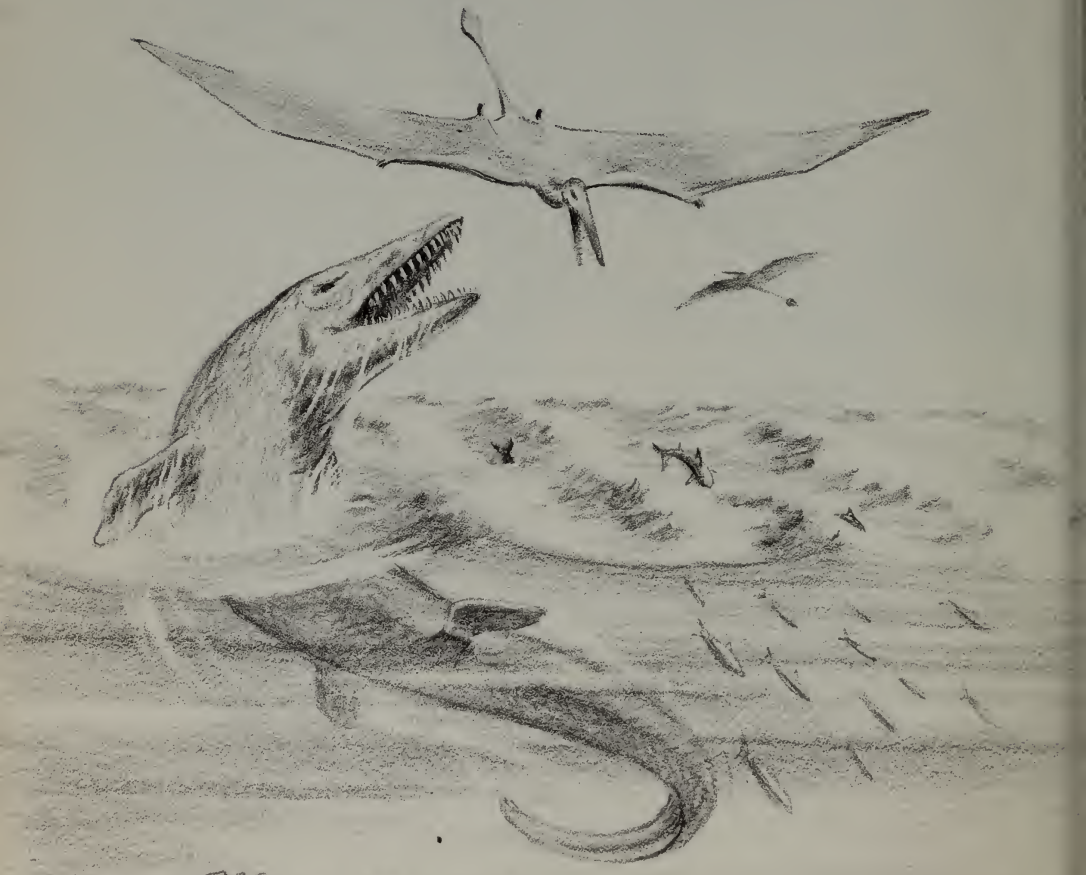
and served trachodon as a rudder when it swam about in search of food. It also had a very large ducklike bill, lined with teeth for grinding the plants before it swallowed them. But trachodon was stupid, slow-moving and unwieldy. Because it was a plant eater and had no instinct to kill, it became easy prey for many of the vicious carnivorous dinosaurs.

First of the mighty killers of the Age of Reptiles was *ceratosaurus*. It lived entirely on the land and walked on its two hind feet, leaving its short front legs free for grasping its prey. With its tremendous mouth and many rows of sharp-edged teeth, it bolted its food in greedy fashion, never bothering to chew it.

Then came *tyrannosaurus rex,* "king-tyrant lizard," the strongest and most fierce creature ever to live on earth. It was fortunate for all the earlier animals of ancient times that this ugly giant did not make its appearance until nearly the end of the Age of Reptiles. For every creature that crossed its path was in danger of being torn apart. Moving swiftly on its long hind legs and using its heavy tail as a powerful

weapon, tyrannosaurus lashed savagely at its prey. Gripping the earth firmly with its great, bird-like feet, it ripped and tore the living flesh from its helpless victims with teeth that were long, strong and razor-sharp. It ruled over the high, dry land and the lake and swamp regions for more than fifty million years. But in the great salt seas lay another kingdom, which it could not enter.

The king of the seas was *mosasaurus,* a giant lizard with great gaping jaws and very sharp teeth. Strong paddle-like legs and a long, powerful tail enabled mosasaurus to swim through the shallow seas with terrific speed. It dined royally on the numerous fish that inhabited its kingdom. Sometimes it was fortunate enough to snatch a flying dragon for its dinner.



Mosasaurus

The flying dragon was not the gigantic creature of fairy stories, belching smoke and fire from its mouth and nostrils, but it was every bit as hideous and strange-looking as any creature ever described. Its name was *pterodactyl*—and it ruled the skies for about one hundred million years.

Pterodactyl had a long, narrow head with jaws which were edged with sharp teeth, for it was carnivorous. It had the body of a land reptile, yet it flew like a bird. It had wings that often measured twenty-five feet, from tip to tip. Its wings were covered by a tough, skinlike membrane, much like that of our present-day bats. On each of its feet it had three sharp-clawed toes, which it used for climbing trees or for clinging to branches and rocks. On the end of its long, slim tail there was a diamond-shaped piece of very tough membrane, which it used as a rudder to guide it through the air. Pterodactyl seldom walked, for on the ground it was slow and clumsy. But in the air it was swift and graceful.

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Then came *archaeopteryx*. It was a very small creature, about the size of a modern pigeon. Like pterodactyl, it had clawlike toes, but its wings and body were covered with feathers, in true birdlike fashion. However, archaeopteryx probably did little flying, for its long tail was made up of vertebrae which made it too heavy to carry on long flights through the air. Archaeopteryx was able to procure food and to escape its enemies only by soaring from tree to tree, as do the flying squirrels today. Thus it became easy prey for

swifter creatures which had begun to inherit the kingdom of the skies. Those creatures were birds, and they apparently had little difficulty in taking over from archaeopteryx, which had ruled, in its clumsy fashion, for more than twenty million years.

The first true birds were better equipped for life than either pterodactyl or archaeopteryx. They had strong, well-developed wings, with bodies that were comparatively small and light of weight. Thus they were able to fly great distances in search of food and shelter. Their eyesight was so keen they were able to detect their enemies from very great distances. Instead of jawbones and teeth, birds had tough, horny beaks. To do the chewing work of teeth, they had a gizzard, or second stomach. The gizzard was lined with a very tough, horny substance which ground their food, making it possible for the birds to swallow their food whole, even while in full flight.

Thus, the true birds, which were so well equipped for life, have been able to rule over the kingdom of the skies for more than sixty million years—while on the face of the earth and in the seas whole families of mighty animals have long since become extinct.

Scientists believe that many families of animals and plants have become extinct because of changes in the earth's weather. Not just daily or seasonal changes such as we experience in our lifetime, but great, slow changes in the earth's climate.

Each time the climate over most of the earth has remained warm and damp for millions of years, new life forms have appeared and flourished because food and water have been plentiful. And each time the climate has remained cold and dry for long periods of time, families of plants and animals have died out from lack of food and water, or have gradually changed in order to survive.

Thus it was that a long period of cold weather eventually brought to an end the rule of the mighty dinosaurs and closed the chapter of life known as the Age of Reptiles.

III THE FAMILY ANIMALS

Sixty million years ago the climate over most of the earth was warm once again. Trees, grasses and many other plants that we know today were thriving in abundance. Insects, fish and birds looked and acted like modern ones. Salamanders, newts, frogs, toads and mud puppies were the only remaining amphibians. And the once-great reptile kingdom had dwindled down to its modern size, leaving only crocodiles, alligators, tortoises, turtles, lizards and snakes. But the greatest change that had taken place in the animal world had been the gradual development of a new kind of creature—the warm-blooded animal known as the mammal.

The most important creatures in the world today are the mammals. The story of their rise from the small, weak animals that fled in terror from the last of the dinosaurs to the strong creatures they are today is the most interesting chapter in the history of our earth. And this chapter covers the period in which we live today—the period known as the Age of Mammals.

We speak of mammals, as well as of birds, as warm-blooded creatures because their blood remains warm all the time, regardless of the temperature of the air or water about them. This constant blood temperature makes it possible for them to move quickly, even in cold weather. Fish, amphibians and reptiles, on the other hand, become slow and sluggish in their movements whenever the temperature becomes cold. When the temperature drops as low as the freezing point, many of them become completely helpless. This is because the temperature of their blood changes with every change in the temperature of their surroundings. Thus, because the mammals adapted more easily to changing conditions than any other creatures, they soon became the rulers of the animal world.

In the beginning mammals were smaller and weaker than many other creatures. When the changing climate caused plants to become too tough for other creatures to digest, the mammals developed teeth with excellent chewing surfaces. Because they continued to eat well, they grew in

size and strength. But, most important of all, the brains of the mammals grew and developed—for they had to use their brains more than the larger, stronger creatures in order to survive.

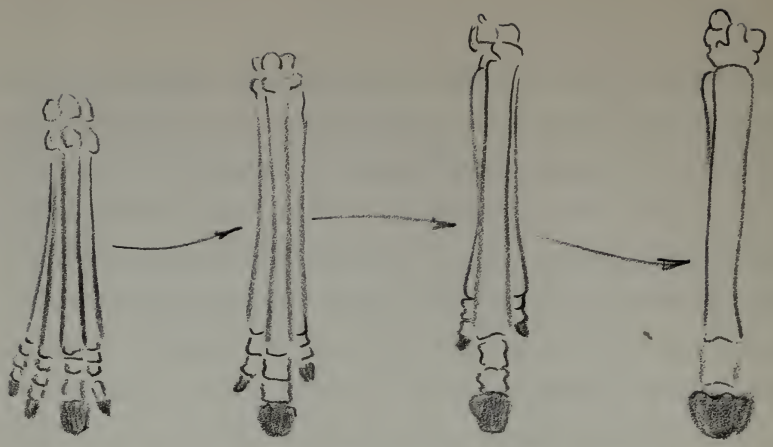
Another great difference between mammals and other animals was that they carried their young within their own bodies in order to feed them until they were fully developed. After birth, young mammals were fed milk from the bodies of their own mothers until they were strong enough to forage for their own food. Their parents taught them how to find the proper foods, as well as how to defend themselves. For these reasons mammals are known as the "family animals."

It is fairly easy to distinguish mammals from any other animals because they are the only creatures with hair. Some mammals, such as the whale and the hippopotamus, have very little hair on their bodies. But many others, like the bear, camel and buffalo, are noted for their shaggy coats. Actually, hair has greatly helped many of the mammals in their struggle for existence, for it has protected their bodies from the icy winds and snow that have brought death to many another kind of creature.

One of the first mammals was a strange little creature called *eohippus,* the "dawn horse." Eohippus actually did not resemble the modern horse. It looked more like a modern dog, with a small body and a curved backbone. Each of its front feet had four toes, its hind feet had three, and all of

its toes had toenails. As eohippus walked the toes spread out, making it able to travel across the spongy, wet ground of the marshlands. For several million years this tiny creature padded about the swampy regions, seeking only the tenderest of plants and grasses for food and hiding from its enemies behind the tall marsh grasses. Then, when the climate once again began to grow colder, many of the tender plants of the swamplands were replaced by tough, coarse grasses and shrubs. So eohippus began to develop teeth that were stronger and better adapted to chewing such harsh foods.

Slowly the swamplands became hard, dry prairies. No longer did eohippus walk with its toes spread out, for it could move much more swiftly over the hard earth by running on the tips of its toes. Because its center toes were the longest, they naturally carried the weight of its body. So the



Lower leg from Eohippus to modern horse

center toes gradually became strong and tough, and the center toenails grew larger and harder. The other toes, not being used at all, finally disappeared. This is how the feet of eohippus, the "dawn horse," eventually became what we call hoofs.

Prairie life brought about other changes in eohippus. Because the open prairies offered few hiding places, it had to run faster and faster to escape its enemies. And so the muscles of its legs, thighs and shoulders became more powerful, its legs grew longer and its body grew larger. Finally eohippus, the small doglike creature, became the large, fleet-footed animal we know today as the horse.

The deep, dark forest had never offered much refuge to eohippus for it was the home of the evil *saber-toothed tiger,* ancestor of the many members of the great cat family and one of the most vicious and cunning animals that ever lived.

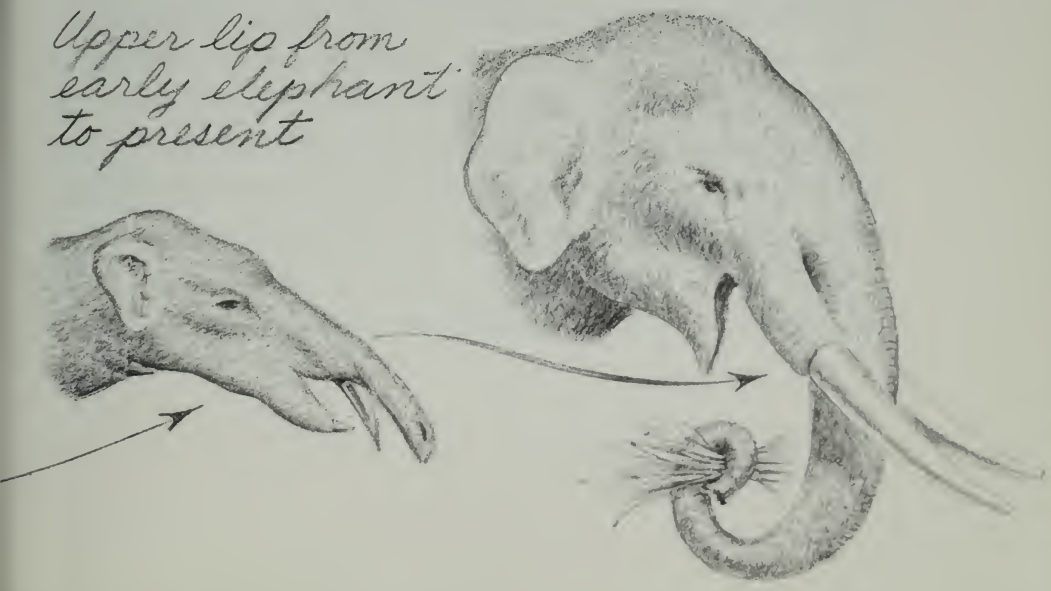
Stalking its prey on soft-soled feet, it moved silently, quickly and with fierce strength. But there was one great difference between the saber-toothed tiger and other members of the cat family. It had two upper teeth which resembled long, curved swords and were often more than twelve inches long. Those upper teeth were strong as steel blades and extremely sharp—and they ripped and tore the flesh of living victims in the most horrible manner. The saber-toothed tiger stalked the grassy plains. It crouched in the forest trees and it sprang from earth and from leafy limb with deadly accuracy, for it was also gifted with excellent eyesight.

The world was a banquet table for the saber-toothed tiger. There were rodents, or gnawing animals, such as squirrels, beavers, rabbits and gophers. There were many kinds of insectivores, or insect-eating animals, whose descendants are the moles, hedgehogs and shrews. There were cattle, sheep and goats—some of them quite like modern ones. There were swine, or pigs. And there were primates, the manlike tree dwellers that we call monkeys, apes and lemurs. While the

saber-toothed tiger may not have dined on all of those choice morsels of living food, nothing that lived was safe from the powerful, cunning "cat"—not even the thick-skinned elephant.

The first elephant was not very well protected from the many dangers which beset it. While it did have thick, tough skin, which was some protection from the sharp claws and teeth of the saber-toothed tiger, it had no other natural weapon with which to defend itself. It was an odd-looking little fellow, about three and one-half feet high, with a body that was both short and stocky. Its neck was long and flexible in order that it might reach the tender plants that grew above the ground. It had tiny flat ears and almost no forehead at all. Because its brain was also small it was probably not very intelligent. Its teeth were similar to those of many other plant-eating creatures of its time, except for the middle teeth, or incisors, which were much longer than the others.

Then the elephant began to change. Its body grew in size and weight until it was able to kill an attacker, simply by crushing it under the weight of one of its giant feet. Its brain also grew, until it finally became one of the most intelligent animals on earth. Its ears grew very large, which made it possible for the elephant to pick up the sound of an approaching enemy while it was still far away. And, while its lower incisors gradually disappeared altogether, its upper incisors grew and grew until they finally became a pair of massive tusks. But strangest of all is what happened to the elephant's upper lip. As its upper lip grew longer and larger and took on a round shape, the elephant's nostrils eventually became enclosed within the end of the lip. All this time, the lip itself remained very flexible. Thus, the elephant at last possessed a trunk—one of the strangest-looking but most useful instruments in nature.



The elephant's trunk is its keen and sensitive nose. It is the hand with which it grasps its food and feeds itself. It is a powerful and unerring arm with which it can push over a full-grown tree, crush an enemy's bones or swat a fly with equal ease. It is an efficient crane with which it can lift great weights and place them, quite accurately, wherever it wishes. And it serves the elephant equally well as drinking fountain and portable shower bath.

The modern wild elephant makes its home in Asia and Africa, where the weather is usually warm. But there was a time when it roamed far and wide across the great plains of the Arctic Circle, for the climate was still warm over most of the earth.

When the climate once again began to grow colder, the elephant gradually developed a thick coat of hair to protect its body from the icy winds and snow. For thousands of years this large, shaggy elephant—known as the *wooly mammoth*—battled against the growing cold. Plants and grasses became more scarce. Thus it became increasingly difficult to find food, or shelter from the bitter winds and whirling snows. Finally, the strongest of the wooly mammoths began moving toward the warmer south, where food was more plentiful and where they eventually lost their coats of fur. Many of their less fortunate relatives, staying behind, died of starvation or were trapped in the deep snow and froze to death. For that was

one of the coldest periods the earth has ever known. It was the Great Ice Age, a long period of time when glaciers—thick sheets of ice and snow—covered many parts of the earth.

While the glaciers of the Great Ice Age brought death and destruction to animal and plant life in many parts of the world, they also changed the face of the lands over which they moved. As they slowly scraped their way across the land, they carried great quantities of rich soil and deposited it in the valleys and on the plains. They filled the great basins of the lowlands with fresh water from their melting ice, forming wide, deep lakes. And the waters of those lakes brought warmer weather to lands where fruits and vegetables could flourish in great abundance.

Scientists tell us that there have been at least four ice ages since the world began, with the climate of the earth becoming warmer after each great ice sheet had crept across the land. They also tell us that it was during the warm period just before the Great Ice Age that a strange new two-legged creature began to walk the earth.

IV THE MASTER CREATURE

One million years ago the climate had again become warm over most of the earth. Trees, grasses and flowering plants had begun to grow closer to the Arctic Circle. And animals once more roamed the great northern plains. Although the face of the earth had been changed by the movement of great glaciers across its surface, life now went on much the same as it had before. For more than nine hundred thousand years animals

enjoyed the warmer climate and abundant food. Then, about sixty thousand years ago, a new kind of enemy began to threaten their existence. This enemy was a two-legged mammal which, ever so gradually, began to rule over the entire animal kingdom.

This new creature was not huge like the dinosaurs or the wooly mammoth. He had no armor plate or heavy spiked tail with which to defend himself. He had neither powerful jaws nor long sharp teeth with which to tear his victims apart. Nor was he strong, as the thundering reptiles were strong. He was small and weak, but he was not defenseless. For this creature possessed a weapon that was far superior to brute strength and armor plate—a weapon that finally made him the master of all the creatures of the earth. That weapon was a superior kind of intelligence, called intellect. And the creature was man.

With his intellect man was able to imagine things he had never seen or heard of. And he was able to invent things that had never been made before. No other creature could do either of those things. However, the most important difference between man and other creatures was that man was able to reason things out and then decide for himself what he would do.

For a long time it was believed that the birthplace of early man was on the great continent of Asia. Scientists call him the Peking man because his fossilized bones were discovered near Peking, China. Along with his bones they found

many crude tools and weapons, which he had undoubtedly used in his daily life. They also found the fossilized remains of animals that lived about one million years ago. But the Peking man may not have been the earliest man on earth.

On the island of Java in 1891 some much older fossilized bones were found. There were a few teeth, a thigh bone and the top of a skull. The teeth were like those of man. The thigh bone showed that the creature had walked upright like man. But the skull was more like that of the modern ape. With those few teeth and bones as a guide, scientists put together a model of what they thought the living creature had looked like. They called it the Java man.

More recent discoveries have led some scientists to believe that the real birthplace of early man may have been in Africa. Fossilized bones of a creature which they call the southern ape-man were found there in 1924, and ever since that time the southern ape-man has been the cause of many discussions among scientists. There are some who think it was an ancestor of man. Others think it was an ancestor of the apes. No one has ever been able to prove what it really was. So scientists continue to battle over the fossil bones of the southern ape-man. And their battles of words lead to even more discussions—about something called evolution.

Evolution means changing or becoming different. The study of evolution teaches that the earth, its climates, its plants and its animals have changed in the past, are changing now and will probably always continue to change. Through long and careful study of soil, rocks, fossils and bones scientists have found proof that many such changes have taken place. They have also found evidence that many changes are taking place even now, though the process is so slow that we are not aware of them. And so scientists today agree that evolution is a fact.

Man has undoubtedly changed during the past sixty thousand years. But scientists believe that even early man was born with an intelligence superior to that of other creatures. He was, however, born entirely without knowledge of his environment, just as he is today. And, because there was no

other creature to teach him anything, man had to learn by experience and by observing the world and the universe about him.

Since he had to eat in order to live, man learned to search for food. At first he knew only of the things that grew near his birthplace. There were nuts, berries and fruits. There were edible roots and herbs. And there were many small animals, the flesh of which he undoubtedly ate raw. He may even have learned what foods were safe for him to eat by observing the eating habits of the birds and other animals.

Because he was uncomfortable in the pouring rain, he learned to seek shelter in natural caves. He found that a cave was drier and warmer than the world outside. So he remained, and the cave became his home.

Because he and his family were in constant danger of being devoured by carnivorous animals, man learned to fight. At first he used his hands and feet. Perhaps he even used his strong sharp teeth. Then he learned to throw rocks and to beat off attackers with stout sticks.

For a long time man lived this simple life. But, because he was man, he was not content. He had so much curiosity that he was constantly learning new things. And he used his new knowledge to make life safer and more comfortable for his family and himself.

Even early man must have known about fire. Surely at times he must have seen lightning strike the trees of the forest.

When he saw the trees burst into flame and the whole forest become a blazing torrent, he knew the power of fire and was afraid. It was probably a very long time before he discovered that this great power, which scorched, burned and devoured the forest, could also be a useful servant to man.

Somehow man learned that he did not have to wait for lightning to strike in order to have fire. He found that he could rub two dry sticks together—or strike two stones, one upon the other—and sparks would shoot out. When he did this over a pile of dried leaves or grasses, fire would spring to life. He found that a fire, built upon a rock or upon barren ground, would not spread and would finally die out unless it was constantly fed with more material to burn. And so at last man learned how to make fire, how to keep it going and how to control it. He also discovered that most animals possess a deathly fear of fire. So he kept a small fire burning at the entrance to his cave home to keep the hungry creatures

at a safe distance. This protective fire also served to keep his family warm. And, probably quite by accident, man discovered that meat was much better when it was held over a fire and cooked. The use of fire was man's first great discovery.

Then man learned that some rocks were much harder than others. He learned to make a stone blade by chipping one rock with another. In this way he began to make tools and weapons of stone. These were man's first great inventions.

Gradually man learned to use his stone instruments to make even better tools and weapons. From ivory, bone and horn he fashioned sewing needles, fishhooks and arrowheads. And from wood he made handles for stone axes and hammers. With his tools he became man the builder and craftsman. And with his weapons he became man the hunter and fisher — master of forest, prairie and stream.

Man the builder continued to improve his living conditions. With ax and hammer he built a ladder with which he could scale the steepest cliff. Then he dug himself a new cave home, high up on the face of the cliff. When he pulled his ladder into the cave at night he was safe from the most ferocious of animals.

With his ax he hollowed out the trunk of a tree, in which he was able to float on the surface of lake, pond or river without getting wet. This was the first boat.

Then he built himself a new kind of home. With his heavy stone hammer, he pounded strong poles into the lake

bottom. He built himself a house of woven boughs and twigs upon the poles and covered it over with wet clay. The clay baked hard in the heat of the sun. This was the first real house.

It was easy for the lake dweller to get to shore, for he had his boat. But he also made sturdy planks of wood from the forest trees, upon which he could walk to shore. These planks were the first man-made bridges.

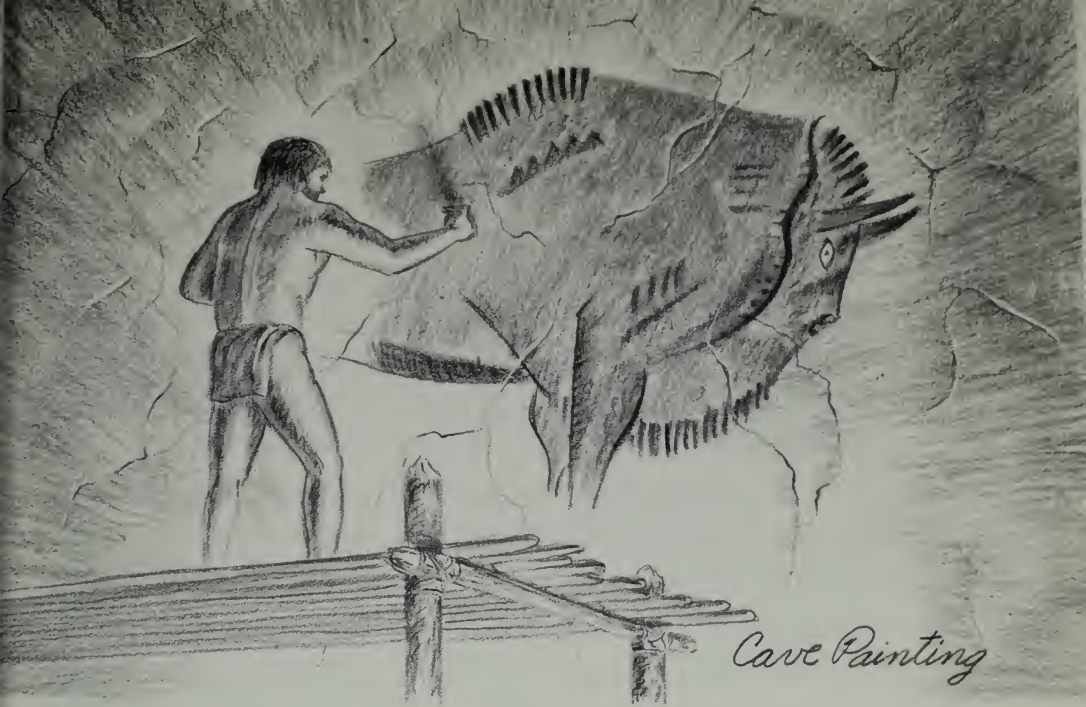
Man the craftsman also did his share to make life more comfortable. He dried the furry hides of the animals he had killed for food. Using the sinews of the animals for thread, he made clothing with his bone and ivory needles. The clothes he made were crude, but they protected his body from the cold.

Then man discovered that fire would bake wet clay into a substance that was as hard as rock. Taking some smooth wet clay, he molded a dish, a jar and a cooking pot. Then he baked them in the fire until they were as hard as stone. This was the first pottery.

Man learned many things during his first few thousand years on earth. But his discoveries and inventions would have died with him had he not been able to speak. He had to have some means of passing on all the knowledge he had gained. At first he probably made only a few noises, deep down in his throat. Then he began to make different kinds of noises, using his tongue and teeth. He developed special sounds for fire, water, rock, wood and all the other things about him. These sounds were the first nouns, or name words.

But soon name words were not enough. As he learned to do things and to make things man needed sounds to express doing and making. These sounds were the first verbs, or action words. Then man needed sounds to describe or to explain things. These sounds were the first adjectives and adverbs.

Every new thing that man discovered or invented and



Cave Painting

every new or strange thing that happened to him brought about new words. And so his list of words grew and grew until at last he was able to express his thoughts, his feelings and everything that happened in his daily life.

But soon a spoken language was not enough for man. He wanted to leave some kind of a record of the things that happened, and so he began to draw pictures. With colored clay he painted hunting and fishing scenes upon the walls of his cave home. With sharp stones and crude tools he scratched other storytelling pictures into the walls. Some of these pictures were quite lifelike and very beautiful. This was the first art.

Early man probably had little thought for art or beauty. With his pictures he was simply trying to tell the story of his daily life. Gradually his pictures became more and more simple in order that he might tell longer stories both more quickly and in a smaller space. Thus his pictures eventually became signs, or symbols. In time, the symbols became the very simple letters of an alphabet. Man had at last learned to write.

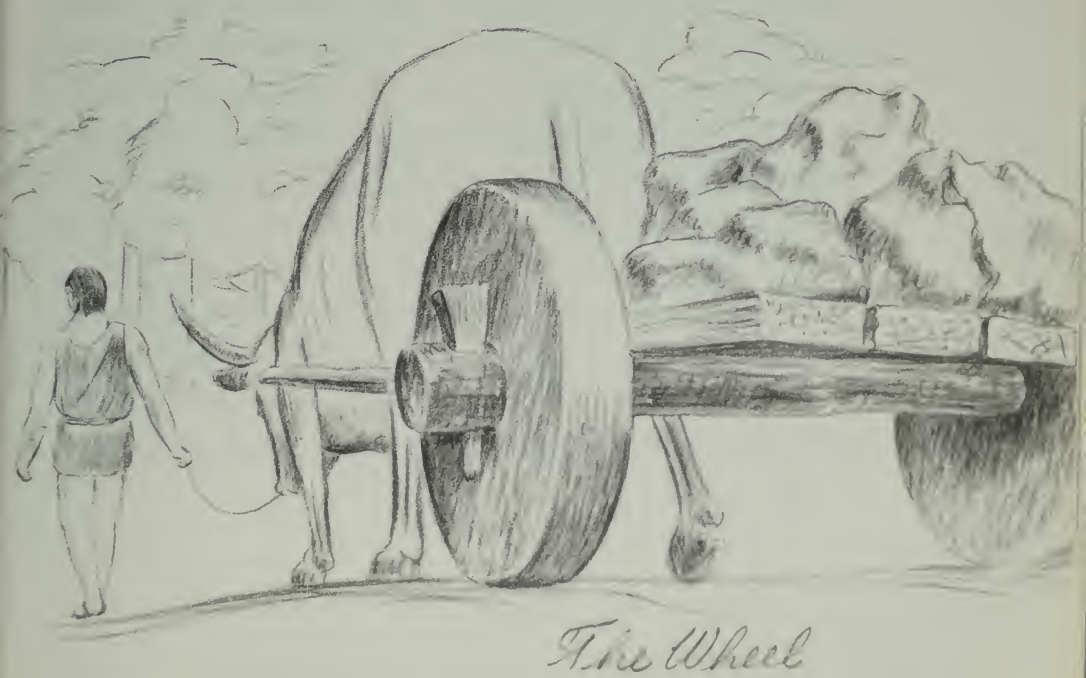
Long before man learned to write he had been harvesting plants for food. But he had never tried to plant a garden, for he did not know where the plants came from. Then he saw that tiny seeds dropped to earth from ripened plants. He saw them sprout in the warm, wet soil. The sprouts pushed upward through the earth, growing and ripening as they reached toward the light of the summer sun. And the full-grown plants bore more seeds to make more plants. Man had at last discovered the magic of seeds.

At first he probably grew only simple plants such as wheat and oats, for they were easy to sow and required little care. But most vegetables needed specially prepared soil and a great deal of water. So man learned to till and to cultivate the soil, as well as to build irrigation ditches to carry water to his fields. Then he became man the farmer.

Farming was difficult, for there was much heavy work to be done. So man learned to tame some of the wild animals and to teach them to help him with his work. He trained

oxen to pull his plow and to drag heavy boulders and logs. But this method of transporting goods was slow, so man invented a device with which his oxen could move heavier loads more quickly.

From the trunk of a large tree he fashioned a pair of flat disks. Through the center of each disk he cut a hole. He fitted one disk over each end of a pole. Through each end of the pole he inserted a strong wooden peg, to keep the disks from sliding off. Then he fastened the pole firmly to a wide, heavy board. This six-piece device was a cart – the first vehicle in the world. And the disks were the first wheels– one of the greatest inventions of all time. Then man harnessed his oxen to the cart and trained them to pull loads that were often many times their own weight.



The Wheel

Man also trained other wild animals. He taught dogs to guard his home and family while he was in the fields. He tamed cows, goats and reindeer, and with their milk he made nourishing cheeses. He tamed sheep and used them for food and clothing. He tended all his animals with great care, for he was now man the shepherd, keeper of flocks.

Then there came to man a new source of wealth and power, but its discovery was probably quite by accident. Somehow man learned that certain kinds of rocks, when heated to an extremely high temperature, would produce a new and wonderful material. This new material was metal. From the moment of its discovery to this very day, metal has been important in the life of man.

For a long time the only metal known to man was copper. Copper could be polished until it shone with a lovely reddish luster. It could be pounded into all sorts of useful shapes, growing harder and tougher with the pounding. But copper did not entirely take the place of stone, ivory and pottery clay, for copper blades and points required constant sharpening. Copper cooking pots melted when the fire grew too hot. And anything made of copper eventually corroded, or wore away, from the action of air and water.

Then man discovered tin—a soft, silver-white metal that would not corrode or tarnish. He melted a little of the tin and mixed it with melted copper. These combined metals formed bronze, the first alloy ever made by man.

Bronze could be polished until it shone like pure copper, and it was easy to pound into different shapes. With every stroke of the hammer, bronze became harder and tougher than copper. Unlike copper it did not corrode, for the tin protected it from the action of air and water. For most purposes, it was superior to stone, ivory and pottery clay.

With bronze man made tools, weapons, cooking utensils, vases and ornaments. On knife and spear handles he carved beautiful designs. And on vases, cooking pots and shields he carved the story of his life. For a period of at least five hundred years bronze was so useful and so important to man that we speak of that period as the Bronze Age.

Then man discovered iron.

Iron was not beautiful. It had no lovely reddish luster,

but was a dull, dark gray in color. And it rusted when exposed to moisture. But iron was more plentiful than other metals and it was easy to separate from the ore, or metal-bearing rock. It was hard and very tough, and it could be pounded into shape quite easily when it was red-hot. Soon iron became so important to man that the whole course of his life began to change.

With iron man began to invent machinery to do his work. With iron he was able to build bigger and stronger buildings, bridges and ships. He learned to make lifesaving medicines, such as tonics for increasing red blood cells and astringents to stop bleeding. Also, with the aid of iron, he was eventually able to harness some of the great forces of nature and to make them do his bidding.

Iron can be found in many different forms. There is iron in soil, rock and water. There is iron in plants and in the blood of all living creatures. There is even iron on other planets, millions of miles from our earth. Pieces of that iron from outer space are constantly hurtling across our skies in the form of meteors or "shooting stars." All these forms of iron are mixed with other elements, for iron combines with other chemicals the moment it is exposed to air and water.

Because man observed that iron combined so freely with other elements, he was able to invent a way to change crude iron into steel.

Steel is actually iron that has been treated with extreme

and constant heat and to which carbon and other chemicals have been added. Steel is stronger and tougher than iron. Depending upon the chemicals that have been added to it, steel can also be either harder or softer than iron. Steel can be polished until its surface shines like smooth glass. It can be rolled into thin sheets or pulled out into wires that are finer than human hair, for steel is flexible. This means that it can be bent or stretched without cracking or breaking. Because steel possesses these almost magical properties, it has been to man what the magic lamp was to Aladdin.

With steel man has accomplished great mechanical and scientific wonders. With this magic metal he has built automobiles, aircraft, suspension bridges, skyscrapers and thousands of the other things that make his life more comfortable. On the other hand, man has also used steel for the construction of powerful guns, torpedoes, bombs and warships that

Making Steel

have brought death and destruction to many parts of his world.

Now man has discovered a new source of wealth, power and destruction, and he has named it atomic energy. This energy, or force, is the greatest discovery of all time for it is the source of all physical power in the entire universe.

Man has already put atomic energy to work, and he has seen its awful power in action. He has seen one atomic bomb destroy an entire city and kill thousands of his fellow men. But he has also put atomic energy to work in other ways to make his world a better place in which to live.

Man is now using atomic energy for better heating, greater electrical power, better manufacturing methods, faster transportation and for the curing of sŏme diseases. What he will eventually be able to do with it is impossible to foretell. But there is a strong possibility that, in the near future, atomic energy will be made so easily and so cheaply that all mankind will be able to benefit from its use.

In the thousands of years that man has walked this earth he has accomplished many great wonders. He has conquered fire and water. He has taught himself to speak and to write. He has learned the magic of seeds. He has trained other creatures to do his bidding. He has built machines to carry him and his possessions wherever he wishes. He has built instruments to carry his voice to all parts of the world. And he has discovered and learned to use the very elements of which the earth is made.

But the greatest of all the accomplishments of man has been his ability either to adapt himself to changing conditions—no matter what those changing conditions have been —or to change conditions to suit himself. All these things only man has been able to do, for he is the only creature to possess a true intellect. And it is this intellect that has made man the master creature of the earth.

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